Practitioner's Docket No. 60680-726 **PATENT**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Werson et al. Group No.: Unassigned
Application No.: 10 / 672,930
Filed: 09/25/03 Examiner: Unassigned
For: ELECTRIC MOTOR

Assistant Commissioner for Patents
Washington, D.C. 20231

TRANSMITTAL OF CERTIFIED COPY

Attached please find the certified copy of the foreign application from which priority is claimed for this case:

Country: United Kingdom

Application Number: 0222394.9

Filing Date: 09-27-02

WARNING: "When a document that is required by statute to be certified must be filed, a copy, including a photocopy or facsimile transmission of the certification is not acceptable." 37 C.F.R. § 1.4(f) (emphasis added).

SIGNATURE OF PRACTITIONER

Reg. No. 41,908

William F. Kolakowski III
(type or print name of practitioner)

Tel. No. (248) 203-0822

Dykema Gossett PLLC
39577 Woodward Avenue
P.O. Address Suite 300
Bloomfield Hills, MI 48304-2820

Customer No.: 26127

NOTE: The claim to priority need be in no special form and may be made by the attorney or agent, if the foreign application is referred to in the oath or declaration, as required by § 1.63.

CERTIFICATE OF MAILING (37 C.F.R. § 1.8a)

I hereby certify that this correspondence is, on the date shown below is being deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231.

Signature

Date: 12/16/03

Linda K. Caraciola
(type or print name of person certifying)

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

As rescanning documents *will not* correct images, please do not report the images to the Image Problem Mailbox.

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed J Evans.

Dated 23 July 2003

Patents Form 1/77

Patents Act 1977
(Rule 16)

THE PATENT OFFICE
A
27 SEP 2002
RECEIVED BY FAX

The Patent Office

27SEP02 E[illegible]390-1 [illegible]
P01/7700 0[illegible]00-0222394.9

1/77

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road
Newport
South Wales
NP10 8QQ

1. Your reference — A10610GB - DJL/ACL/lh

2. Patent application number *(The Patent Office will fill in this part)* — 27 SEP 2002 — 0222394.9

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

   Automotive Motion Technology Limited
   Fellows House, Royce Close
   West Portway Industrial Estate
   Andover, Hampshire
   ST10 3TS

   07378147001
   Patents ADP number *(if you know it)*

   If the applicant is a corporate body, give the country/state of its incorporation — United Kingdom

4. Title of the invention — Electric Motor

5. Name of your agent *(if you have one)*

   Forrester Ketley & Co.

   "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

   Chamberlain House
   Paradise Place
   Birmingham
   B3 3HP

   Patents ADP number *(if you know it)* — 133005 ✓

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

   a) any applicant named in part 3 is not an inventor, or
   b) there is an inventor who is not named as an applicant, or
   c) any named applicant is a corporate body.
   See note (d))

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	-
Description	7
Claim(s)	3
Abstract	1
Drawing(s)	2 only

CF

10. If you are also filing any of the following, state how many against each item.

Priority documents	-
Translations of priority documents	-
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	-
Request for preliminary examination and search *(Patents Form 9/77)*	One
Request for substantive examination *(Patents Form 10/77)*	-
Any other documents *(please specify)*	-

11. I/We request the grant of a patent on the basis of this application.

Signature: Forrester Ketley & Co.

Date: 27 September 2002

12. Name and daytime telephone number of person to contact in the United Kingdom: David Lucking 0121 236 0484

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) If you need help to fill in this form or you have any questions, please contact the Patent Office on 08459 500505.

b) Write your answers in capital letters using black ink or you may type them.

c) If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.

d) If you have answered 'Yes' Patents Form 7/77 will need to be filed.

e) Once you have filled in the form you must remember to sign and date it.

f) For details of the fee and ways to pay please contact the Patent Office.

PATENTS ACT 1977

A10610GB-DJL/ACL

Title: Electric Motor

Description of Invention

The present invention relates to an electric motor, in particular to means of mounting magnetic field producing elements on an external rotor of an electric motor.

It is known to attach magnetic field producing elements such as permenant magnets to the inside of a cylindrical wall of a motor rotor by means of generally T-shaped bars. A head of each bar engages with an edge of the magnet whilst a stem of each bar is attached to the rotor wall, for example by welding. As each bar has to be individually connected to the rotor wall, the process of attaching the magnets to the rotor is time consuming and hence expensive. Moreover, care must be taken during assembly to ensure that no movement of the magnets with respect to the rotor is permitted.

A further disadvantage of rotors assembled in this way is that when used in an electrically commutated motor such as a brushless DC motor, the torque exerted on the rotor as a result of the magnetic field generated by coils in the stator pulses. As a result, the rotor tends to vibrate whilst rotating and vibration pulses are set-up. This causes the motor to be undesirably noisy, and is a particular problem when the motor is used in applications in which the rotor rotates at relatively high speeds, for example when the motor is used to drive a steering pump.

According to a first aspect of the invention, we provide an electric motor including a rotor with a generally cylindrical rotor wall and a plurality of magnetic field producing elements mounted on an inside surface of the rotor wall, the rotor being mounted for rotation around a central stator, wherein the magnetic field producing elements are mounted on the rotor wall by means of a plurality of resilient retaining members, at least one resilient retaining member

being located between and engaging with edges of two adjacent magnetic field producing elements, the edges of the magnetic field producing elements extending generally parallel to an axis of rotation of the rotor, the resilient retaining members being elastically deformed so as to exert a retaining force on the magnetic field producing elements.

Thus, by virtue of the invention, there is no need to weld or otherwise attach a retaining bar to the rotor wall, and thus the magnets may quickly and easily be mounted on the rotor wall.

The electric motor is preferably an electrically commutated motor such as a brushless DC motor.

It has been found that, by virtue of the fact that such retaining members permit some movement of the magnets relative to each other and to the rotor wall, any vibration pulses, such as those produced due to torque pulses produced in an electrically commutated motor, tend to be damped, and thus a motor having a rotor according to the first aspect of the invention tends to be less noisy in use than comparable prior art electric motors.

Preferably, the magnetic field producing elements are permanent magnets.

Preferably, the edges of the magnetic field producing elements are shaped to conform to the shape of the resilient retaining member, as this permits a greater area of the edges of the elements to engage with the retaining member, and hence may further assist in retaining the magnetic field producing elements on the rotor wall.

Each resilient retaining member may include a first and a second portion each with a first edge and an opposite second edge, the two portions being joined along their first edges and inclined relative to one another at an angle of between 0 and 90°. In this case, each resilient retaining member is preferably arranged with the second edges of the first and second portions directly adjacent to the rotor wall, and the first portion engaging with a first magnetic

field producing element and the second portion engaging with a second adjacent magnetic field producing element.

Alternatively, each resilient retaining member may be a roll-pin.

Preferably, the magnetic field producing elements are elongate and arranged with their longitudinal axes generally parallel to the axis of rotation of the rotor wall, in which case, each resilient retaining member is preferably elongate and is preferably arranged with its longitudinal axis generally parallel to the longitudinal axes of the magnetic field producing elements. In addition, each resilient retaining member preferably extends along substantially the entire length of the magnetic field producing elements.

According to a second aspect of the invention we provide a method of assembling a rotor for an electric motor, the rotor being adapted in use to rotate about an axis of rotation, the method including the steps of positioning two magnetic field producing elements against an inside surface of a cylindrical wall of the rotor, inserting a resilient retaining member between edges of the two magnetic field producing elements which extend generally parallel to the axis of rotation of the rotor, the resilient retaining member being elastically deformed during insertion such that once in place it exerts a retaining force on the magnets.

The invention will now be described by way of example only with reference and / or as shown in the accompanying drawings of which,

FIGURE 1 is an illustration of a cross-section through a rotor and stator of a prior art electric motor,

FIGURE 2 is an illustration of a cross-section through rotor and stator of an electric motor according to the invention,

FIGURE 3 is an illustration of part of a cross-section through a second embodiment of rotor for an electric motor according to the invention,

FIGURE 4 is an illustration of part of a cross-section through a third embodiment of rotor for an electric motor according to the invention.

Referring now to the drawings there is shown a rotor 10 and a stator 12 for an electric motor, preferably for an electrically commutated motor such as a brushless DC motor. Both the rotor 10 and stator 12 are generally cylindrical, and the rotor 10 is arranged concentrically around the stator 12.

The rotor 10 includes a generally cylindrical rotor wall 13, which is mounted for rotation about its longitudinal axis A by conventional means (not shown), and a plurality of magnetic field producing elements 14, which in this example are permanent magnets 14, mounted around the entire circumference and on an inside surface of the rotor wall 13. Each magnet 14 is an elongate and is arranged with its longitudinal axis parallel to the longitudinal axis A of the rotor 10. The transverse cross-section of each magnet 14 has the shape of a segment of an annulus, and thus each magnet 14 has two opposite curved faces and two opposite planar edges.

In the prior art arrangement, the magnets 14 are mounted on the rotor wall 13 by means of a plurality of retaining bars 16'. Each retaining bar 16' has a T-shaped transverse cross-section, and has a stem 16'a which extends between two adjacent magnets 14 radially inwardly of the rotor wall 13, and a head 16'b which engages with a top surface of an edge of each magnet to retain the magnets 14 with respect to the rotor wall 13.

The stem 16'a of each retaining bar 16' is attached to the rotor wall 13 by welding or other such method, and therefore attaching the retaining bars 16' on the rotor wall 13 is time consuming. Moreover, care must be taken when attaching the retaining bars 16' to the rotor wall 13, to ensure that the retaining bars 16' clamp down on the magnets tightly enough completely to prevent movement of the magnets 14 with respect to the rotor wall 13. In addition, when in use in an electrically commutated motor such as a brushless DC motor, pulses in the torque exerted on the rotor 10 by coils within the stator 12 cause the rotor 10 to vibrate and vibration pulses to be set up, which significantly increases the noise generated by the electric motor.

Referring now to Figures 2 to 4, according to the invention, however, the magnets 14 are mounted on the rotor wall 13 by means of a plurality of resilient retaining members 16, there being at least one retaining member 16 between each pair of adjacent magnets. Each retaining member 16 is elastically deformed so as to exert a retaining force on the magnets 14.

In the embodiments shown in Figures 2 and 3, each retaining member 16 is an elongate element with a V-shaped transverse cross-section. Thus, each retaining member 16 has a first and a second portion each with a first edge and an opposite second edge, the two portions being joined along their first edges and inclined relative to one another, in this example at an angle of approximately 30° although another angle between 0° and 90° may be adopted. The retaining members 16 are made from a material such as spring steel.

Each retaining member 16 is arranged between two adjacent magnets 14 with a longitudinal axis generally parallel to the longitudinal axis A of the rotor wall 13, with the second edges of the first and second portions adjacent to the rotor wall 13, and the first portion engaging with the edge of one magnet 14 and the second portion engaging with the edge of the adjacent magnet 14. In this example, each retaining member 16 extends along substantially the entire length of the magnets 14.

The size and number of magnets 14 are such that the gap between adjacent magnets is too small to receive the retaining member 16 without the retaining member 16 being elastically deformed to bring the first and second portions closer together. Thus, when in place between adjacent magnets, the first and second portions of the retaining member 16 push outwardly against the magnets 14 and hence exert a retaining force on the magnets 14. When all the magnets 14 and retaining members 16 are in place, this retaining force is sufficient to retain the magnets 14 in position around the rotor wall 13.

As it is not necessary to attach each retaining member 16 to the rotor wall 13, mounting of the magnets 14 on the rotor wall 16 is considerably

simplified over the prior art arrangement described above. Moreover, it has been found that, as some limited movement of the magnets 14 relative to each other and to the rotor wall 13 is permitted, any vibration pulses are damped, and hence a electrically commutated motor according to the invention, tends to be quieter than a prior art arrangement.

In order to increase the area of contact between each retaining member 16 and the adjacent magnets 14, it is possible to shape the edges of the magnets 14 to conform with the shape of retaining members 16.

For example, as shown in Figure 3, the edges of the magnets 14 may be inclined so that they do not lie radially with respect to the rotor wall 13, but instead lie substantially parallel to the first and second portions of the retaining members 16.

The retaining members 16 also need not have a V-shaped cross-section, and any similar spring arrangement may be used instead. For example, the retaining members 16 may be a roll-pin as shown in Figure 4.

In the example shown in Figure 4, the edges of the magnets 14 are each provided with a generally semi-circular recess which is adapted to receive part of a retaining member 16. This is not, however, necessary, and magnets 14 of the configurations shown in Figures 2 and 3 may be used with a retaining member 16 having a generally circular cross-section.

Whilst in the above examples, each retaining member 16 extends along substantially the entire length of the magnets 14, the retaining members 16 may be shorter than the magnets 14, provided they supply sufficient retaining force to retain the magnets 14 on the rotor wall 13. Alternatively, if desired, two or more short retaining members 16 may be provided between each pair of adjacent magnets 14.

The magnetic field producing elements 14 need not be permenant magnets. They may instead include an element which can be induced to produce a magnetic field, such as a magnetizable element or electrically

conducting coil, in which case, the rotor 10 may be used in a switched reluctance motor.

The rotor wall 13 typically is made from sheet metal, but may instead be made from a composite material comprising a viscoelastic material sandwiched between two sheets of metal. Such a material is commercially available under the name BONDAL®. The use of such a material is particularly advantageous in an electric motor according to the invention, as it further reduces the vibration noise produced by the rotor 10 when in use. It is believed that the frequency of vibrations generated by movement of the magnets 14 and the frequency of vibrations generated by the composite rotor wall 13 are such that the vibrations at least partially cancel each other out, and hence the noise produced by the motor when in use is further reduced.

The invention is particularly useful when the motor is used in applications in which the rotor must rotate relatively fast, for example when the motor is used to drive a steering pump in a motor vehicle.

The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, as appropriate, may, separately, or in any combination of such features, be utilised for realising the invention in diverse forms thereof.

CLAIMS

1. An electric motor including a rotor with a generally cylindrical rotor wall and a plurality of magnetic field producing elements mounted on an inside surface of the rotor wall, the rotor being mounted for rotation around a central stator, wherein the magnetic field producing elements are mounted on the rotor wall by means of a plurality of resilient retaining members, at least one resilient retaining member being located between and engaging with edges of two adjacent magnetic field producing elements, said edges of the magnetic field producing elements extending generally parallel to an axis of rotation of the rotor, the resilient retaining member being elastically deformed so as to exert a retaining force on the magnetic field producing elements.

2. An electric motor according to claim 1 wherein the motor is an electrically commutated motor.

3. An electric motor according to claim 1 or 2 wherein the magnetic field producing elements are permanent magnets

4. An electric motor according to any preceding claim wherein the edge portions of the magnetic field producing elements are shaped to conform to the shape of the resilient retaining member.

5. An electric motor according to any preceding claim wherein each resilient retaining member includes a first and a second portion each with a first edge and an opposite second edge, the two portions being joined along their first edges and inclined relative to one another at an angle of between 0 and 90°.

6. An electric motor according to claim 5 wherein each resilient retaining member is arranged with the second edges of the first and second portions directly adjacent to the rotor wall, and the first portion engaging with a first magnetic field producing element and the second portion engaging with a second adjacent magnetic field producing element.

7. An electric motor according to any preceding claim wherein each resilient retaining member is a roll-pin.

8. An electric motor according to any preceding claim wherein the magnetic field producing elements are elongate and arranged with their longitudinal axes generally parallel to the axis of rotation of the rotor wall.

9. An electric motor according to claim 8 wherein each resilient retaining member is elongate and is arranged with its longitudinal axis generally parallel to the longitudinal axes of the magnetic field producing elements.

10. An electric motor according to claim 9 wherein each resilient retaining member extends along substantially the entire length of the magnetic field producing elements.

11. An electric motor substantially as hereinbefore described with reference to and / or as shown in the accompanying drawings.

12. A method of assembling a rotor for an electric motor, the rotor being adapted in use to rotate about an axis of rotation, the method including the steps of positioning two magnetic field producing elements against an inside surface of a cylindrical wall of the rotor, inserting a resilient retaining member between

edges of the two magnetic field producing elements which extend generally parallel to the axis of rotation of the rotor, the resilient retaining member being elastically deformed during insertion such that once in place it exerts a retaining force on the magnetic field producing elements.

13. A method of assembling a rotor for an electric motor substantially as hereinbefore described with reference to the accompanying drawings.

14. Any novel feature or novel combination of features hereinbefore described and/or as shown in the accompanying drawings.

ABSTRACT

Resilient mounting for magnets on an outer rotor of a motor

An electric motor includes ; a rotor (10) with a generally cylindrical rotor wall (13) and a plurality of magnetic field producing elements (14) mounted on an inside surface of the rotor wall (13), the rotor (10) being mounted for rotation around a central stator (12), The magnetic field producing elements (14) are mounted on the rotor wall (13) by means of a plurality of resilient retaining members (15), at least one resilient retaining member (16) being located between and engaging with edges of two adjacent magnetic field producing elements (14), The edges of the magnetic field producing elements (14) extend generally parallel to an axis of rotation (A) of the rotor (10), and the resilient retaining members(16) are elastically deformed so as to exert a retaining force on the magnetic field producing elements (14). The mounting reduces vibration and noise in pmdc motors, e.g. in steering pumps.

(Figs. 2, 3 & 4.)

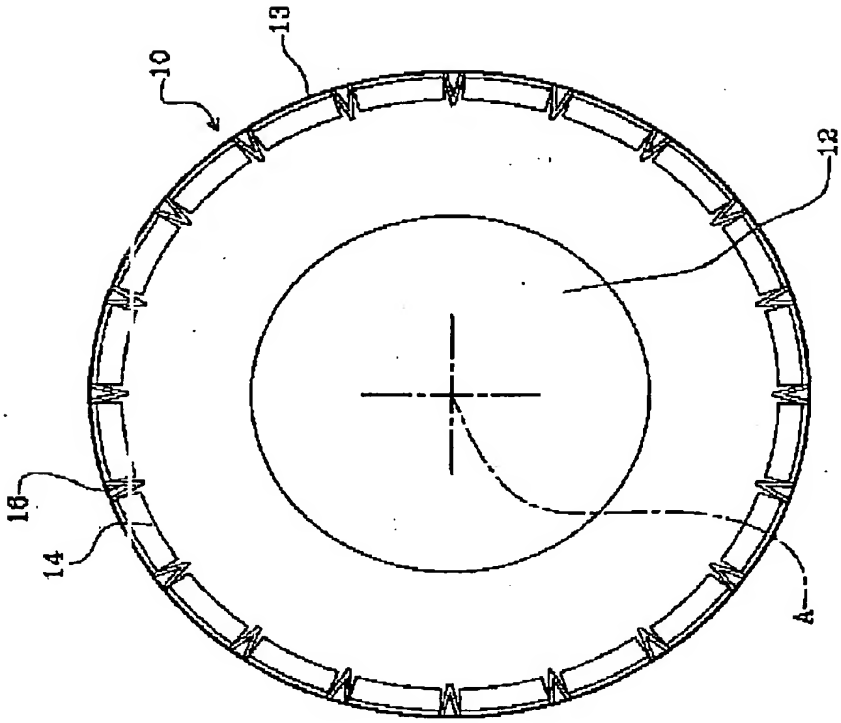

FIG 2

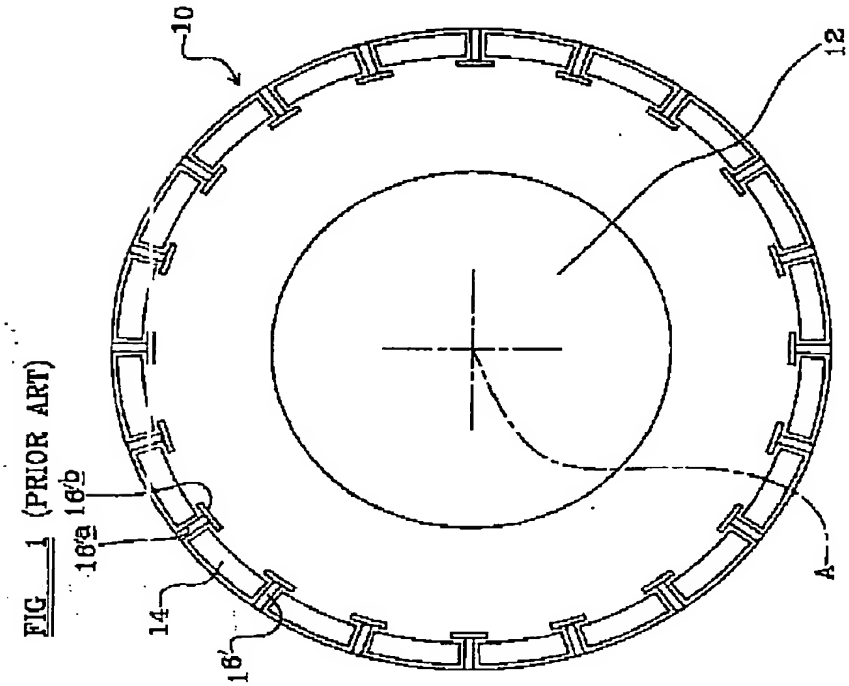

FIG 1 (PRIOR ART)

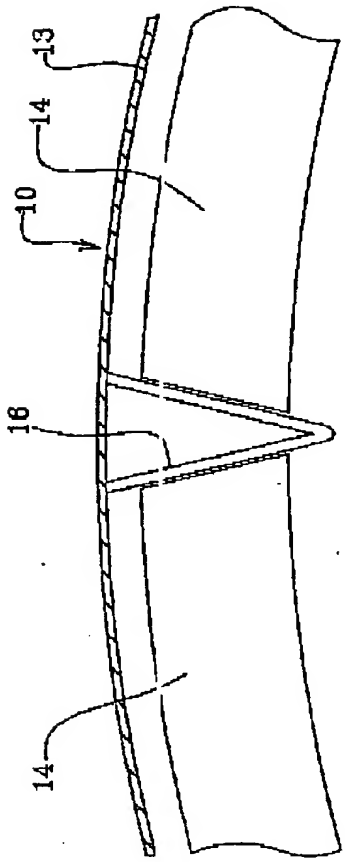

FIG 3

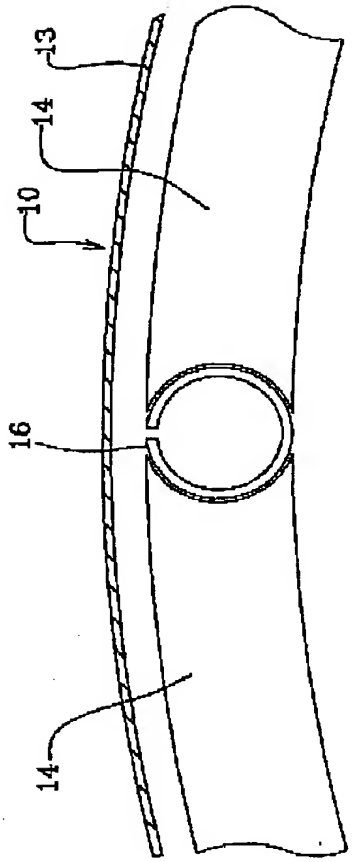

FIG 4